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ABSTRACT

In 1974, the Women's Educational Equity Act expanded math, science, and technology programs for all females. Current reform movements focus on providing more equitable education by changing the curriculum, teaching, and assessment. Research suggests that girls and boys currently receive different education and that girls have less exposure to science equipment than boys. The Sisters in Science (SIS) Program focuses on fourth and sixth grade students, its goals being to increase: (1) interest, achievement, self-esteem, environmental awareness, career awareness, and attitudes in the areas of mathematics and science; (2) inservice and preservice teachers' knowledge of the relationship between gender and effective instruction; and (3) parental knowledge of the importance of science and mathematics education in the lives of their children. (Contains 36 references.) (YDS)

The Sisters in Science Program: A Three Year Analysis

by

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THE SISTERS IN SCIENCE PROGRAM: A THREE YEAR ANALYSIS

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Introduction

The Sisters In Science(SIS) program is an educational intervention aimed primarily at increasing the attitudes, perceptions, and achievement of fourth and fifth grade girls in science and mathematics. SIS is one of over 40 science education programs for Women and Girls, sponsored by the National Science Foundation (NSF). NSF is one of several government-funded programs established to address gender inequality in science and mathematics education.

Monies for programs like SIS came into existence via the passage of legislation. Such government actions included Title IX of the Education Amendments Act. Passed in 1972, Title IX was enacted to address the inequities in educational programs receiving federal dollars. In 1974, the Women's Educational Equity Act was passed. It expanded math, science, and technology programs for females. In 1994, a package of gender-equity provisions was included in the Elementary and Secondary Education Act. Among the provisions was the creation of teacher training activities that worked to eliminate inequitable practices and to develop programs to increase girls' participation in math and science (Parkay & Hardcastle-Stanford, 1998).

While legal barriers to achieving gender equity have been removed, there are often barriers we still face. These are barriers of the mind. Reform has been on the national agenda in science/mathematics education for more than a decade. The national reform movement has trickled down to state and local boards of education through the

development of state and local science/mathematics curriculum standards that not only advocate specific content but also equitable education. As schools search for the best models of instruction to help teachers become effective teachers, they are incorporating the standards into their curriculum. School administrators have little disagreement about the need for reform , but they have little agreement about the specific modes to achieve this reform (Linn, 1990). A commonly agreed-upon theme for reform is the active involvement of learners. Given a teacher's central role in the classroom, it is reasonable to hypothesize that the classroom culture is a function of a teacher's conceptions of not only science/mathematics but also equitable practice. Therefore, teachers are central to solutions and successes for current reform efforts. Unless we understand teachers' conceptions, why they hold them, and constraints in changing them, we will find it impossible to move from reformed curriculum to reformed practice. Therefore, teachers' conceptions must be examined as they reflect upon and apply the principles of reform. Furthermore, successful modes of achieving reformed practice must be examined.

Current science education reforms have focused on changing the curriculum, teaching and assessment in K-12 education to make it more equitable (National Research Council, 1996; Rutherford and Ahlgren, 1990). Specifically, the National Science Education Standards emphasize the "development of environments that enable students to learn science that provide equitable opportunities for all students to learn science" (National Research Council, 1996 pp. 4,7). However, recent studies on equitable practices in the classroom tell a different story of the current educational climate (Eder, Evans & Parker, 1995' Orenstein, 1994; Pipher, 1994). While much of the science education reform literature acknowledges the central importance of "equity issues", the

discussion centers around a "color-blind" points of view (Cochron-Smith, 1995; Ladson-Billings, 1995; Rodriques, 1997) rather than acknowledging differences in students. The Association for Educators of Teachers in Science indicate in their Professional Knowledge Standards that "unless prospective and practicing teachers can develop the knowledge, skills and beliefs called for in the reform documents little will change" (AETS, 1996). While the standards address the issue of equitable practice in the classroom they fail to capitalize on the importance of preparing teachers to issues of equity in the classroom. Methods for equitable practice must be embedded into the reform initiatives to ensure that all students are given the best possible change for success.

Rationale

At the start of SIS the research literature was full of reasons and remedies for gender inequity in science and mathematics. One such line of research focused on the classroom environment. Studies suggested that within classrooms, males and females receive a very different education (Jones & Wheatley, 1990). Girls have less exposure to science equipment than do boys. Girls also become less active in science classes as they progress through the grade levels (Klein, 1991). Another avenue of inquiry suggested that teacher education programs featuring gender related instruction was lacking. Having examined the students' course project, Mader & King found that students advocated gender related instruction to a greater degree than they actually included it in their own teaching (Mader & King, 1995).

Perceptions about self and others were also mentioned as causes of disparities in the classroom. Shakeshaft (1995) says that science education classes have expectations

that simply exclude girls leading to lower participation and achievement. Teachers' beliefs about students' abilities were said to affect the manner in which female students operate in the classroom (Shepardson & Pizzini, 1992). Such research identified teachers as the agents of gender bias. Jones and Wheately (1990) looked at a variety of teacher behaviors during science instruction. They concluded that the manner in which the teacher praised students, responded to call outs, warned students, and questioned students differed by gender. Likewise female students also tended to differ from their male cohorts in their receptivity to and participation in science education to the extent that female students contributed less often to classroom discussion than their male classmates do. A girl's perception of science also contributes to inequity in achievement. It has been found that female students harbor stereotypical ideas about science and scientists. They often feel that science is a male dominated field (Hammrich, 1996).

Reformists believe that there are some essentials to encouraging female student success by building gender-sensitive classrooms. They include fostering a safe and nurturing environment, promoting problem-solving skills, building math confidence creating collaborative experiences, using hands-on learning and allowing for open discussion about gender stereotypes, acknowledge the contributions and barriers of women in science , to utilize female-appropriate teaching and learning strategies, making math careers interesting and relevant (Allen, 1995; Mann, 1994, Boland 1995, Martin).

Constructivism, an epistemological perspective of knowledge acquisition, serves as the foundation for many of the noted suggestions regarding female-friendly science education. By definition, of which there are many, constructivism is an approach to teaching. Constructivist believe that children learn by doing. Learning involves

changing pre-existing schema using new information acquired through varied experiences (Damon et al., 1997).

Von Glasersfeld (1995) suggests that although Jean Piaget was noy the first to speak about this way of knowing, he did spend years establishing the basis for a dynamic constructivist theory of knowing (p. 6). Piaget's notion of concept development suggested that humans come to know and understand their world through their personal experiences with and within it. Based in the theory of constructivism, Von Glasersfeld (1983) offers suggestions for teaching and learning. The first recommendation is that teachers should create an environment where individuals must interact both cognitively and physically with the environment in order to learn. Also, teachers must access students' prior knowledge to determine a suitable starting point for instruction. Wheately (1991) extends Von Glasersfeld's suggestions by stating that teachers should allow students to actively construct relationships and patterns, and work in cooperative learning groups. In addition, teachers should make material meaningful for students. Finally, science and mathematics institutions should be activity oriented and problem-centered in nature.

"Science For All Americans" a groundbreaking report written by the American Association for the Advancement of Science set new standards for science, mathematics and technology education. This report on effective learning has offered several principles of learning that are founded in constructivist pedagogy.

What then should educators do to foster science learning in a constructivist fashion? Driver (1995) offers science education some suggestions. She posits that learners need to be given access to physical experiences as well as concepts and models

of conventional science. Teachers need to be the presenters of experiences that enable students to make mental connections to pre-existing events. Driver's list by suggesting that students should have opportunities to: express themselves in oral and written form, work in teams, solve problems, question, explore and discover concepts, use authentic tools, and learn about related professions and professional contributions to the field.

Constructivist theory has also been expanded to include the training of science educators Neureither (1991) also believed that teachers should create scientist-like instructional experiences for students; understand and use the standards set by the American Association for the Advancement of Science; establish high standards for all learners. Teachers should model attitudes that foster inquiry and knowledge; and seek ways to connect science learning to other disciplines (Neureither, 1991).

Program Description

The Program

The rationale for SIS has its foundations in research on gender and achievement in science. Research suggests that female students have been found to lag behind their male counterparts in science achievement, this is due in part to science education practices that run counter to the intuitive learning style of female students. In addition, females tend to view the field of science as a male domain, often leading to the reluctance of girls to pursue science as a field of study or a career (Hammrich, 1996). In response, SIS aims to serve female students with the intention of increasing girls' self-esteem, generating positive attitudes about science, interest in science careers, and sense of social responsibilities with regard to the environment.

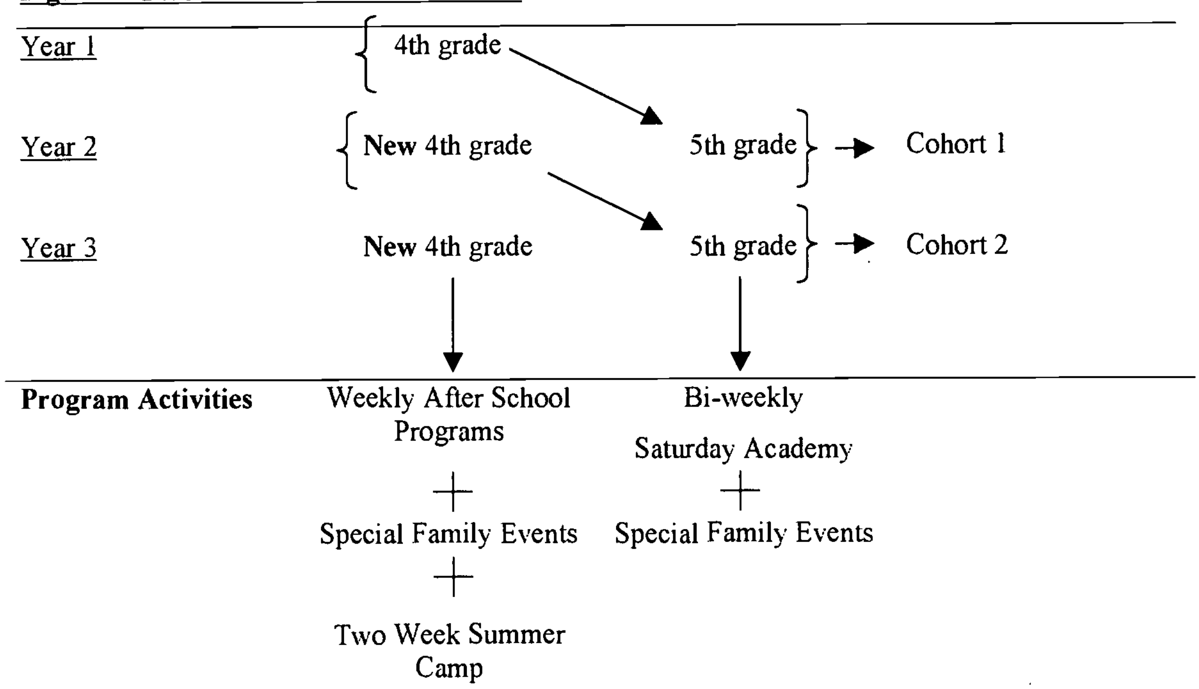
The SIS intervention focused first on fourth-grade female students because research has found that female students, as young as nine years old, lag behind their male counterparts in science achievement for a variety of reasons (Hammrich, 1996). Research from the National Science Foundation (1990) and the Task force on Women, Minorities, and Handicapped in Science and Technology (1989) note that while efforts have been made to narrow this gap in achievement, little change has been realized (Hammrich, 1996).

Sister In Science, a best practices model of effective integrated science and mathematics instruction, grew out of several years of research and testing. Two years prior to the funding of the existing "experimental" program there was a "model" program which was funded by NSF. The model program ran from 1995-1997 and served as the basis for the creation of the "experimental" program. The "model" program involved training preservice teachers to deliver effective science and mathematics instruction for inner city girls in an after school program and developing and piloting several science and mathematics activities.

Inherent in the existing program's focus is the recognition that female-specific intervention programs have a lasting impact on school success (Kaplan & Aronson, 1994). The program's efforts are also consistent with the call for systemic educational reform that recognizes gender-related, learning style-differences in science and mathematics (Tamir, 1988; Versey, 1990). Others involved in systematic educational reform include the American Association for the Advancement of Science, the American Association of University Women, the Midwest Consortium for Mathematics and Science Education, the National Research Council, and the National Science Foundation.

The present "experimental" program, both a refined and expanded version of the "model" program, was designed under the guides of existing research findings on gender sensitive, constructivist, integrated science and mathematics instruction. SIS was funded to run from August 1, 1997 to August 1, 2000. The program was conducted in 6 elementary school each year. In year one, fourth-grade teachers, their female students, and the families of the girls participate in the program. In year two, rising fourth graders (i.e., fifth-graders) received additional program services while new fourth grade girls began the program. In the three years of program implementation two student cohorts encountered the full program intervention. In addition, fourth and fifth grade teachers received training and follow-up support in the delivery of the aforementioned "female-friendly" brand of instruction. (see figure 1 below)

Figure 1. Two Year Intervention Model



The SIS program provided fourth- and fifth-grade girls with cooperative interdependent science exploration. The rationale being, when girls are allowed to work

in a manner that is intrinsic to their collective learning style (e.g., with the manipulation of materials) learning will occur. Additionally, the program's designers were interested in the reformation of girls' perceptions of science education and science as a career option via reflective discussion as well as hands-on experience with science.

The goals of SIS include (1) increasing interest, achievement, self-esteem, environmental awareness, career awareness and attitudes in the area of mathematics and science (2) increasing inservice and preservice teachers' knowledge of the relationship between gender and effective instruction and (3) increasing parental knowledge of the importance of SEM in the lives of their children.

Program Components. In order to attain these goals, the SIS program has four major components: (a) an in-school constructivist and gender-sensitive science program; (b) an after-school enrichment program for the fourth grade girls; (c) a Saturday academy for the fifth grade girls; and (d) a "city rivers exploration" summer camp.

The components of the program work in concert to provide 4th and 5th graders with a physical environment that is both psychologically, emotionally and socially safe and accessible to all students. The activities themselves engage students in instructional experiences that challenge everyone involved. The activities clearly connect subject matter to real-world issues that are culturally relevant to students. Whereas in the past, "a curriculum" has often meant a set of answers to be transferred from teacher to student, the curriculum as outlined in the SIS program is a set of questions to be posed to a class (Skilton Sylvester, 1997). In this way, the process of inquiry is co-constructed by the students and teachers and fosters a true community of learners. During each component of the program, students take responsibility for generating and gathering "data," posing

questions and problems, generating possible explanations and proposing methods for evaluating the best explanations. Across all of the events, teacher, parents, volunteers, and Temple University students are providing a level of mentoring that extends the students learning base beyond the walls of the classroom.

The *in-school program* was conducted for two hours a week for each classroom at each of the six schools. Classroom activities focused on the urban environment and used gender sensitive approaches to teaching science/mathematics. As part of the program's teacher enhancement component, Students in science education methods courses at Temple University facilitated the program sessions with the classroom teacher. The preservice teachers' coursework explored gender-equity issues in the classroom, the constructivist approach to learning, and the community service learning concepts presented in the program.

The *after-school program* was conducted from 3:00-4:30 p.m. one day per week in each of the six schools. The program coordinator facilitated the after-school component with assistance from graduate and undergraduate elementary education students and members of the intergenerational volunteer corps. The after-school component extended the classroom activities by focusing on the concepts of systems, constancy/change, model, and scale. The students also engaged in reflection activities designed to help them better understand their personal learning, challenge stereotypical notions about science, and develop critical thinking skills. These reflective activities included writing and interactive discussions.

The *summer program* was conducted for two weeks during July to reinforce learning that occurred during the academic year. Fourth grade females spent two weeks

exploring the city rivers. Activities included taking four field trips to environmentally focused sites in the area, mapping local waterways, creating model rivers, and designing improvement plans to prevent the city rivers from becoming polluted. At the end of the summer program, the girls shared their learning with their families and other students from neighborhood elementary schools.

The *Saturday academy program* was conducted on Saturdays for four hours at a local site. Activities focused on expanding what the fifth grade girls learned during year one of the intervention. The fifth grade activities were designed to introduce a more technology focus and a sport component. Sample activities that the girls participated in were taking apart and putting back together computers, developing web pages, and learning how to play tennis and fencing and learning the science and mathematical principles behind each sport. The fifth grade activities tied mathematics, science, and technology together.

Each of the central studies of the SIS program is structured around one or more central questions, which provides a focal point for the classes' inquiry. Each central study is woven by both unifying themes and cross-cutting competencies. The four unifying themes are: systems, models, scale, and constancy/change. The unifying themes constitute those skills that allow people to play effective roles in the community. For example, in the context of the classes' study of city rivers, students learn about *systems* as they study the water cycle. Along the way, the students discover the three states of matter: liquid, solid, and gas, a lesson which is fundamental to understanding *constancy and change*. Students learn about *models* as they create their own rivers. In creating their model of the river, students need to utilize the principal of *scale*.

The five cross-cutting competencies are: participatory citizenship, communication, multicultural competencies; problem-solving; and school-to-career readiness, technological literacy (School District of Philadelphia, 1996). In the study of city rivers mentioned above, students ask the question: "How do the city rivers get clean so that people can drink the water?" In searching for answers to this question, students engage in visiting a city water treatment plan, researching (with the help of the Internet) ways of making drinking water safe, and writing local scientists for their answers and suggestions. This lesson involves *problem solving, technological literacy, participatory citizenship* , and *communication*. We might also ask, "How do different groups of people make the best of the city drinking water?" This might lead to learning about different ways of life of different ethnic groups, a lesson that "culture" is about values, beliefs and practices that guide our daily lives -- helping students develop *multi-cultural competencies.* SIS worked to meet its goals through a variety of activities.

Other components of the program that acted to reinforce the student program components included (a) teacher training program; (b) preservice training program; (c) family education program; and (d) volunteer corps.

The aim of the *teacher training* was for fourth-grade (Year one) and fifth-grade teachers (Year two) to increase their knowledge of the relationships between gender and effective instruction. These teachers, called cooperating teachers, are taught how to deliver gender-sensitive constructivist integrated mathematics/science instruction. Thirty-one teachers from six different schools located in Philadelphia's inner city participated in SIS over the past three years. Teachers participated in summer institutes each summer that focused on equitable best practice. At the end of each summer institute the teachers

along with the science educators developed activities and guidelines to follow in the classroom the following year. Teacher participated in regular academic curriculum meetings throughout the year. The teachers' role during the academic year was multi-faceted. They taught equitable best practice science and mathematics lessons along with supervising education elementary practicum students three hours a week as part of the in school part of the program.

The goal of the *preservice teacher training* was to increase their knowledge of the relationships between gender and effective instruction while engaged in the experiences of their practicum. Through the practicum and methods coursework and interactions with their cooperating teachers Temple students are made aware of the connections between gender and effective instructional practices. They are also taught how to deliver integrated mathematics/science instruction. The preservice teachers worked in teams to instruct 4^{th} and 5^{th} grade students under the supervision of cooperating teachers one day each week.

The *family education* program participants and their families attend quarterly events throughout the year. These events reinforced and showcased students learning throughout the academic year. Events included a science night, a trip to the New Jersey State Aquarium, an overnight at the Franklin Institute, and an end of the year awards banquet.

The *volunteer corps* included retired and working science and science-related field professionals working with program participants. These retired and active science professionals interact with the girls in order to develop the students' connections with science and science-related careers and professions.

Program Evaluation

Method

For the purposes of this research the program will be evaluated in a Gestalt like fashion as the sum of its parts. The parts or components include (1) the student component (2) the teacher component (3) the preservice teacher component and the (4) family education component. However, the following questions transverse the aforementioned components of the program.

Process Evaluation

1 Who are the participants in the program?

2 What are the activities of the individuals who participate in the program?

3 What is the nature and source of the instruction/information imparted to the participants?

Outcome Evaluation

1 Did girls increase their attitudes, interests, and achievement in mathematics and science?

2 What are fourth grade teachers' conceptions of science/mathematics teaching?

3 Were teachers' conceptions of science/mathematics teaching influenced as they confront the gender gap?

4 Did parents and guardians gain knowledge of mathematics and science?

Instrumentation

Multiple data collection procedures were employed to assemble information that addressed the research questions. Information collected on students consists of demographics, attitude, perceptions, and achievement. At the start of each school year

students completed the Fourth Grade Student Demographic Survey. Pre-post test instrumentation was used to measure achievement as well as attitudes. Achievement was measured by an integrated mathematics/science, open ended, hands-on skills test designed around the science process skills. SIS staff constructed the skills and demographic instruments. The skills test content reflected materials contained in the fourth and fifth grade curriculum of the School District of Philadelphia. Attitudes were measured by the Science Attitude Scale, a 30 item instrument with a 5-point likert response scale (strongly disagree to strongly agree) (Meyer & Koehler, 1988). Finally, student perceptions were measured by the Draw A Scientist (DAST) instrument (Mason, Kahle, & Gardner, 1989)

Data collection activities for the teacher component began with a demographic instrument, subsequent focus groups and a pedagogy checklist. The Cooperating Teacher Demographic survey was constructed by the SIS staff. The semi-structured and open-ended focus group questions were designed to elucidate teachers' conceptions of science/mathematics and their perceptions of confronting the gender gap. Teachers completed two 2-hour focus group sessions each academic year. The first focus group was conducted half way through the school year and the second focus group was conducted at the end of the school year. During the focus groups teachers were asked to reflect upon their conceptions about science and mathematics. They were also asked to reflect on any changes that occurred in their practice and the consequent impact their instruction had on their students. Teacher's instructional activities were measured using a Classroom Teacher Observation Checklist. The 25-item checklist, administered in the spring of each year, sought information on teacher-student interactions, conceptual

change-pedagogy, atmosphere and activity type. The items were based on gender-sensitive research. The observations were done at the teacher's convenience therefore they may not have represented a typical performance.

The preservice teacher component data collection activities were numerous. A demographic survey was conducted along with a Pretest/Posttest Practicum Student Surveys. Again, the demographic survey was constructed by SIS staff. Preservice students were surveyed at the start each semester regarding prior knowledge of constructivism and gender equity. They were asked to indicate (a) "none" (b) "some" or (c) "extensive" for two questions: "What knowledge do you have of gender equity issues in the classroom?" and "What knowledge do you have of constructivist learning?" At the end of each semester the preservice students were surveyed on a variety of issue. Questions of concern to this investigation asked whether or not preservice teachers were exposed to issues of gender equity, integrated instruction, or constructivist pedagogy in the classroom and from where they received their information.

Data collection activities for the family education component consisted of event logs, and satisfaction surveys. At the end of each event program participants and their families were asked what they liked and what they would change about the event. In addition they were asked rate their experience on a three point scale of poor, fair, or good.

Data Analysis

With respect to the student component the analysis was primarily quantitative. Pretest-posttest comparisons were done at each grade level for the Science Attitude Scale, the DAST, and the achievement (ie., skills) test. T-test for independent samples were

performed for the attitude scale and the achievement test, while percentages were used to determine differences in perceptions on the DAST. The student data was analyzed in two cohort years (1997-1999 and 1998–2000).

The inservice teacher component focus group data was analyzed using grounded theory (Strauss, 1987). Focus group responses were videotaped, transcribed and coded in a data file using Ethnograph v4.0. Cases were examined as a whole. Extensive memoing and preliminary assertions were logged as focus group responses were conducted, transcribed, read, and re-read to find words, phrases and themes that reflected teachers conceptions concerning science/mathematics teaching and perceptions of confronting the gender gap. The focus group responses were analyzed using Patton's (1990) method for generating themes. Through the constant comparative method (Strauss, 1987) themes emerged and assertions developed. From these preliminary assertions were made and data was highlighted as to possible warrants to support these assertions. Coding of data included both inter-rater and intra-rater reliability as well as several other provisions for trustworthiness.

Finally each teacher was observed implementing an equitable best practice science and mathematics lesson during the spring of each school year. Each observer filled out a predetermined observation checklist to note the occurrence of gender-sensitive, constructivist, and integrated science and mathematics instruction. Frequency counts and percentages were done on each item of the checklist. Counts and percentages were also calculated for each subscale.

Family education and preservice teacher data analysis was primarily quantitative. Frequency counts were used to determine patterns and other commonalties in data for both open-ended and closed-ended questions.

Results. There were a total of 2,037 students participating in the program with an average of 54% (1,100) girls for the total three years. Both the boys and girls participated in the in school portion of the program. In year one there were a total of 166 fourth grade girls from the six schools who participated in the after-school program and 36 fourth grade girls who participated in the summer program. In year two there were a total of 95 fourth grade girls who participated in the after school program, 44 fifth grade girls who participated in the Saturday academy, and 42 fourth grade girls who participated in the summer program. In year three there was a total of 96 fourth grade girls who participated in after school program, 36 fifth grade girls who participated in the Saturday academy, and 38 fourth grade girls who participated in the summer program. (see tables 1 and 2)

Table 1.

Student Demographic Information Years 1997-2000

Item	Response Category	Percentages		
		1997-1998	1998-1999	1999-2000
		N=577	N=790	N=670
Gender	Males	43%	48%	46%
	Females	57%	52%	54%
Ethnicity	African American	64%	67%	63%
	Caucasian	2%	2%	1%
	Puerto Rican	19%	19%	17%
	Indian	1%	2%	1%
	Asian	9%	9%	8%
	Mixed/Other	5%	2%	9%

Table 2.

Demographic of Girls by Program Component

Component	1997-1998	1998-1999	1999-2000
After school	N = 166	N = 95	N = 96
Saturday Academy		N = 44	N = 36
Summer Program	N = 36	N = 42	N = 38

The student data was divided into two 2 year cohorts 1997-1999 and 1998-2000. For cohort one (1997-1999) there were 299 fourth grade girls who completed the attitude pre assessment and 259 fourth grade girls who completed the attitude post assessment. For year two, the fourth grade girls now fifth grade girls there were 215 completed attitude pre assessments and 208 completed attitude post assessments. Table 3 shows that there was a significance found between the fourth grade girls scores pre to post . There was also a significance found between the fourth grade girls pre and their post fifth grade scores. For cohort two (1998-2000) there were 207 fourth grade girls who completed the attitude pre assessment and 211 fourth grade girls who completed the attitude post assessment. For year two, the fourth grade girls now fifth grade girls there were 103 completed attitude pre assessments and 87 completed attitude post assessments. Table 3 shows that there was a significance found between the fourth grade girls scores pre to post. There was also a significance found between the fourth grade girls pre and their post fifth grade scores. The responses were scored 1 = strongly disagree, 2 = disagreed, 3 = neutral, 4 = agree, 5 = strongly agree. Scores above 3.0 indicate the students agreed or strongly agreed with the statements on the subscale.

Table 3.

Science Attitudes Scale Mean Scores

	Pre	Post
Cohort 1		
4^{th} (yr 1)	3.88(n=299)	3.96*(n=259)
5^{th} (yr 2)	4.03 (n=215)	3.99* (n=208)
Cohort 2		
4^{th} (yr 2)	3.71(n=207)	3.88* (n=211)
5^{th} (yr 3)	3.91 (n=103)	3.90* (n=87)

* significant difference $p < .05$

The students perceptions for cohort one and cohort two were measured by the Draw a Scientist test (Mason, Kahle, & Gardner, 1989). The occurrence of characteristics for each drawing were counted (see Table 4). On both the pre and post tests for both cohort years a majority of the girls drew female scientists. There was no significant change. What is interesting to note is that the cohort one girls in their 5^{th} grade year drew more gender neutral scientists then either scientists as girls or boys.

Table 4.

Percentages of Responses for Draw A Scientists Test

	Draws Male (DM) Draws Female (DF)	Pre	Post
Cohort 1		(n=266)	(n=239)
4^{th} (yr 1)	DM	19%	20%
	DF	71%	71%
		(n=214)	(n=179)
5^{th} (yr 2)	DM	9%	13%
	DF	27%	31%
Cohort 2		(n=186)	(n=199)
4^{th} (yr 2)	DM	27%	12%
	DF	30%	57%
		(n=177)	(n=125)
5^{th} (yr 3)	DM	18%	23%
	DF	66%	72%

* significant difference $p < .05$

For cohort one (1997-1999) there were 276 fourth grade girls who completed the skills pre assessment and 226 fourth grade girls who completed the skills post assessment. For cohort year two, the fourth grade girls now fifth grade girls there were 247 completed skills pre assessments and 233 completed skills post assessments. Table 5 shows that there was significance found between the fourth grade girls scores pre to post on the total test score, skills 1, 3/4, 5, 7/8, and 9-12. There was no significant difference

found between the fourth grade girls pre and their fifth grade post scores. However, significance was found between the fifth grade girls scores pre to post for the total test, skill 2, and 3/4. For cohort two (1998-2000) there were 333 fourth grade girls who completed the skills pre assessment and 344 fourth grade girls who completed the skills post assessment. For cohort year two, the fourth grade girls now fifth grade girls there were 148 completed skills pre assessments and 130 completed skills post assessments. Table 5 shows that there was a significance found between the fourth grade girls scores pre to post on the total test score, skills 2, 3/4, and 6. There was also a significance found between the fourth grade girls pre and their post fifth grade scores on the total test core and skills 1, 5, 6, and 9-12. When looking at the fifth grade girls scores there were significant difference found pre to post on the total test score and skill 6.

Table 5.

Means for Skills Test

		Cohort 1				Cohort 2			
		4^{th} (yr 1)		5^{th} (yr 2)		4^{th} (yr 2)		5^{th} (yr 3)	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
Skill	Max. Points	n=276	n=226	N=247	N=233	N=333	N=344	n=148	n=130
1	5	4.46	4.60*	4.57*	3.51	4.53	3.45	4.52	4.66**
2	4	3.66	3.69	3.47	3.71*	3.45	3.76*	3.50	3.46
3/4	4	3.00	3.28*	3.12	3.34*	3.12	3.45*	3.25	3.25
5	4	1.58	2.26*	1.14	1.05	1.88	2.16	2.22	2.33**
6	3	.97	.96	.80	.80	.81	.82*	.78	.92**
7/8	6	3.43	3.72*	3.68*	3.43	3.74*	3.49	2.32	3.78
9-12	12	2.95	4.46*	2.85	3.82	3.00	4.00	3.71	5.09**
Total	38	20.21	24.40*	20.40	20.80*	20.53	21.14*	22.06	23.50*

- * significant difference pre to post ($p<.05$)
- **significant difference pre to post ($p<.05$) between cohort pre and post

Note: Skill 1 – observation, Skill 2 – symmetry, Skill 3 & 4 – Classification, Skill 5 – measuring, Skill 6 – averaging, Skill 7 & 8 – predictions, Skill 9-12 – experimental procedures.

Results were also obtained on the Stanford Nine national test. All fourth grade classrooms take this national test each year (note. 1999-2000 year data was not yet available for this presentation). There was a gain on the scores for each school for each

year of the intervention. No statistical test was run to see if their was a significant difference on the gain scores (see Table 6).

Table 6.

Stanford Nine Point Scores for Fourth Grade

	Baseline	Year 1	Year 2
Schools	1996-1997	1997-1998	1998-1999
Childs	71.3	72.5	65.7
Clymer	43.9	51.6	79.7
Dunbar	56.5	63.5	66.1
Ferguson	55	63	63.7
Morrison	70.5	79.2	81.9
Olney	62.6	77.5	78.9

There were a 31 total teachers who participated in the program over the three years of the intervention. In year one there were 17 fourth grade teachers in years two and three there were 25 fourth and fifth grade teachers each year. These numbers represent teachers who were involved in the program for the entire three years and other teachers who participated one or two years. Of all the teachers who participated in the program they had varied demographic exposure to program components prior to the program.

Table 7.

Cooperating Teacher Demographic Survey

Item	Response Category	1997-1998	1998-1999	1999-2000
		N=17	N=25	N=25
Gender	Male	6%	4%	4%
	Female	94%	94%	96%
Ethnicity	African American	41%	20 %	24%
	American Indian/Alaskan	0	0	0
	Hispanic	0	0	4%
	Asian American	6%	4%	4%
	White	53%	76%	68%
	Other	0	0	0
Certification K-12	K-8	88%	76%	76%
	1-6	6%	12%	0
	K-6	6%	12%	24%
Highest Degree Earned	Bachelors	12%	16%	44%
	Masters	53%	44%	28%
	Masters +30	35%	40%	28%
	Doctorate	0	0	0
Certified to Teach	Elementary Math	35%	6%	4%
	Elementary Science	29%	52%	4%
	Middle School Math	0	16%	8%
	Middle School Science	0	8%	8%
	Elem Math and Science*	24%	0	48%
Years of Teaching	0-5	35%	28%	48%
	5-9	6%	36%	16%
	9-15	6%	20%	20%
	16-25	35%	16%	12%
	25+	18%	0	4%
Science Classes in College	Astronomy	0	12	8%
	Chemistry	18%	40%	48%
	Physical Science	30%	28%	40%
	Physics	18%	24%	28%
	Geology	30%	16%	24%
	Biology	47%	52%	28%
	Oceanography	6%	0	4%
	Other	6%	12%	12%
Non-Science Major Credit Hours	9-12	47%	16%	68%
	15-18	0	72%	4%
	18-21	24%	4%	4%
	21-25	0	4%	0
	25+	0	4%	4%
	8 or less*	12%	0	0

Results gathered from the teacher observation were used to judge the effectiveness of the intervention. Results showed that there has been a real change on the part of the teachers over the three years of the program. Specifically, teachers reported that as a result of the cooperation between the schools and the university, they were continurally teaching science and mathematics more often and more effectively; promoting connections with other subject areas, adopting more gender equitable constructivist approaches to teaching science and mathematics, and changing their own attitudes about science and mathematics in a positive direction (see Table 8).

Table 8.
Classroom Teacher Observation Checklist

Item	Yr 1 n=16	Yr 2 n=27	Yr 3 n=5*
Interactions			
Teacher equally engages boys and girls in dialogue.	100%	59%	100%
Teacher interacts equally with boys and girls.	100%	52%	100%
Teacher equally encourages boys and girls to accept the same roles in the classroom	94%	41%	80%
Teacher listens to boys and girls equally.	100%	52%	80%
Teacher equally acknowledges boys and girls' responses/explanations.	100%	37%	60%
Students work in a cooperative manner.	75%	37%	80%
Boys and girls do similar tasks in the classroom.	100%	96%	100%
Average	96%	53%	86%
Conceptual Change-Pedagogy			
Teacher equally engages boys and girls in higher order thinking.	94%	15%	80%
Teacher assesses prior knowledge.	94%	15%	80%
Teacher confronts misconceptions.	88%	30%	80%
Teacher corrects misconceptions.	88%	11%	40%
Teacher accepts more than one right answer.	94%	19%	80%
Teacher equally asks open-ended questions of boys and girls.	94%	11%	60%
Teacher equally encourages boys and girls to initiate questioning.	31%	0	40%
Average	83%	16%	66%
Atmosphere			
Diverse images of scientist/science careers are present (gender, race/ethnicity, age).	13%	34%	60%
Teacher makes references to science and careers in science.	31%	15%	60%
Teacher connects classroom activities to real life experiences for students.	81%	74%	80%
Average	42%	41%	67%
Activity Type			
Activities are hands-on.	75%	74%	100%
All students use authentic tools and manipulatives to solve problems.	75%	70%	100%
Activities are cooperative in nature.	75%	70%	100%
Activities integrate math and science skills.	56%	52%	100%
Teacher accepts a variety of student performance outcomes.	36%	70%	80%
Teacher allows for student exploration.	81%	81%	60%
Teacher allows for student lead instruction.	25%	22%	80%
Activities are structured.	94%	96%	100%
Average	36%	67%	90%

In response to the focus group reflective dialogue sessions there was seen real change on the part of the teachers conceptions of science and mathematics teaching and in confronting equity issues during the course of instruction. Teachers' conceptions change from indifference to acknolwedgement to embrancement of teaching for all throughout the three years of program implementation.

Table 9.
Select Comments from Focus Group Sessions

Questions	Fall 1997	Fall 1998	Fall 1999
Were you able to teach more science?	• No additional science taught • Two teachers had additional science prep periods	• 11 teachers stated they taught additional science	• Teachers are becoming better mentors and also more aware of what constitutes a good lesson
Has your teaching change? How?	• More of an awareness • Self reflection • Have acquired new strategies • More hands on • Girls are more involved	• More hands on • More coordination with science teachers • Began to model Temple students methods of delivery and lesson plans • Students engaged in more scientific process and more research	• Teachers say they don't tell as much. • They are learning to let the students make mistakes • Many of the teachers said that they are integrating science into their other subjects like reading and language arts
Has your teaching become more gender sensitive? How?	• Tried to utilize different learning styles beyond gender issues	• Yes it is more gender sensitive • Become more conscious of calling on students • More equitable • Students became more interested	• Many of the teachers who were in the program for three years stated that they feel their teaching style encompasses the issue of gender equity • New teachers to the program are becoming more aware
Are you more comfortable with science teaching?	• yes	• yes	• Yes, but I am always learning

There were over 600 preservice teachers who participated in the program over the course of the three years of implementation. In order to account for their conception changes as a result of their participation several instruments were administered. In this paper we selected a random sample of students for three semesters of the six semesters of program implementation. A survey at the beginning of their involvment in the program revealed a mixture of demographics and a lack of knowledge of the pedagogical principles employed in the program. (see table 10).

Table 10.
Preservice Teacher Survey and Demographics

Items		Fall 1997	Fall 1998	Fall 1999
		N=92	N=82	N=79
Year	Freshman	0	0	1%
	Sophomore	0	0	0
	Junior	12%	4%	9%
	Senior	87%	95%	91%
	no response	1%	1%	0
Status	Full-time	95%	96%	2.5%
	Part-time	0	2%	86.1%
	No response	5%	2%	11.4%
Methods Course Completion	Math Ed 141	19%	18%	5.1%
	Science Ed 151	33%	6%	11.4%
	Other	32%	0	41.8%
	Math/Science	9%	0	7.6%
	Two or more	17%	0	31.6%
Teaching Experience	Practicum +/-	98%	83%	70.1%
	None	1%	17%	3.8%
	Other	1%	0	49.4%
	No response	0	0	0
Knowledge of Gender Equity	None	13%	4%	3.8%
	Some	74%	83%	79.7%
	Extensive	13%	13%	16.5%
	No response	0	0	0
Knowledge of Constructivism	None	32%	13%	13.9%
	Some	57%	7%	77.2%
	Extensive	10%	77%	8.9%
	No response	2%	3%	0
				17.7%
Knowledge of Developmental Issues	None	21%	7%	17.7%
	Some	73%	76%	70.9%
	Extensive	5%	13%	10.1%
	No response	1%	4%	1.3%

At the end of each semester the preservice teacher completed post survey to find out the nature of their instruction during the semester of their involvement in the program and where they obtained the information. (see table 11, 12, 13).

Table 11.
Preservice Teacher Post Survey Fall 1997 N=101

TOPICS	**Math 141**	**Science 150**	**practicum supervisor**	**cooperating teacher**	**other**
gender sensitive instruction	36%	55%	35%	17%	26%
assessment techniques	65%	56%	40%	19%	36%
cooperative learning	67%	65%	54%	37%	37%
hands-on/minds-on activities	68%	76%	56%	37%	31%
demonstration activities	62%	67%	47%	24%	18%
lesson plan development	58%	68%	53%	18%	34%
unit development	58%	60%	54%	19%	18%
classroom management techniques	37%	31%	54%	45%	39%
leading group discussions	33%	36%	34%	24%	30%
questioning techniques	51%	51%	44%	30%	34%
benchmarks/standards	45%	84%	31%	13%	17%
adaptive instructional strategies	54%	49%	35%	24%	26%
authentic activity development	58%	61%	36%	21%	29%

Table 12.
Preservice Teacher Post Survey Fall 1998 N=93

TOPICS	Math 141	Science 150	practicum supervisor	cooperating teacher	other
gender sensitive instruction	51%	45%	56%	24%	18%
assessment techniques	73%	49%	36%	35%	22%
cooperative learning	74%	56%	45%	49%	26%
hands-on/minds-on activities	76%	72%	36%	35%	18%
demonstration activities	74%	67%	28%	32%	16%
lesson plan development	70%	56%	49%	30%	21%
unit development	66%	44%	39%	23%	24%
classroom management techniques	64%	38%	51%	45%	22%
leading group discussions	45%	39%	33%	24%	18%
questioning techniques	58%	58%	32%	28%	19%
benchmarks/standards	74%	64%	37%	19%	10%
adaptive instructional strategies	57%	47%	31%	24%	21%
authentic activity development	69%	55%	32%	24%	18%

Table 13.
Preservice Teacher Post Survey Fall 1999 N=41

TOPICS	Math 141	Science 150	practicum supervisor	cooperating teacher	other
gender sensitive instruction	22%	18%	21%	15%	4%
assessment techniques	34%	20%	15%	14%	6%
cooperative learning	36%	25%	19%	21%	6%
hands-on/minds-on activities	37%	32%	17%	25%	5%
demonstration activities	31%	26%	15%	17%	5%
lesson plan development	32%	24%	22%	18%	4%
unit development	32%	20%	9%	13%	4%
classroom management techniques	25%	12%	23%	28%	3%
leading group discussions	16%	13%	11%	13%	4%
questioning techniques	21%	19%	20%	21%	7%
benchmarks/standards	36%	31%	19%	10%	5%
adaptive instructional strategies	26%	22%	15%	15%	3%
authentic activity development	27%	21%	15%	20%	2%

Each year of program implementation there were four quarterly family events.

Events inclued a science night, a trip to the New Jersey State Aquarium, an overnight at

the Franklin Institute, and an awards banquet. At each event the families were surveyed to determine their level of satisfaction with each event. (see table 14)

Table 14.
Family Education Activities. Attendance and Satisfaction Survey Results

Activity	1997-1998		
	Attendance	Average Rating	Average Percentage
Science Night	N=70	1	87%
NJ State Aquarium	N=90	2	12%
Franklin Institute	N=80	3	1%
Awards Banquet	N=84		
Activity	**1998-1999**		
	Attendance	Average Rating	Average Frequency
Science Night	N=218	1	86%
NJ State Aquarium	N=65	2	12%
Franklin Institute	N=100	3	2%
Awards Banquet	N=75		
Activity	**1999-2000**		
	Attendance	Rating	Frequency
Science Night	N=270	1	92%
NJ State Aquarium	N=100	2	7%
Franklin Institute	N=84	3	1%
Awards Banquet	N=137		

Discussion

Summary of Findings

Results of the Science Attitude Scale showed that the girls attitudes toward science and the possibility of pursuing a career involving some aspect of science and/or mathematics were positive before program implementation. Anecdotal information regarding the girls revealed that while they enjoyed science and perhaps someday wanted to become a doctor or have a career in science, they were not aware that it was necessary to take science classes in the future. Therefore their attitudes did not match their understanding of how science courses fit into their eventual career path. However, their

expressed positive attitude towards science is consistent with the research that states girls at this age level tend to enjoy science (AAUW, 1992). In the 5th grade of each cohort year the fifth grade girls attitude continued to be positive and significantly higher than the fourth grade girls attitude. This maybe due to the fact that these fifth grade girls participated in fourth grade and chose to participate again in year two in the fifth grade.

Regarding girls perceptions of science, the girls tended to draw female scientists both pre and post. What was noticed in year two of cohort one was that a majority of the girls tended to draw gender neutral scientists. This is an observation that needs to be further explored.

Results from the science/mathematics process skills instrument in cohort one indicated a mixture of statistically significant changes for the girls participating in the program. This was a combination of small losses and small gains for the six schools involved. We entered each school with a commitment to service all 4th grade classrooms. Therefore no control groups existed within the schools. In other words no "control vs. experimental' group analysis was warranted. Clearly, to the extent that the instrument was appropriate to the problem, a majority of the outcomes did meet the expectation of an increase in the science process skills. Of the skills tested, all of them appeared in the fourth and fifth grade Philadelphia curriculum.

Achievement was also measured using the grade four Stanford Nine science scores. All six schools 4th grades tested at each school saw an increase in their scores over the years of SIS intervention. No statistical test was run on the data. Stanford Nine scores are published by the School District for public consumption each year. In year one there was a range of growth scores for the six schools from 1.2 to 14.9 with the average gain

score 7.9 overall. In year two the range of increase for the schools was from 1.2 to 35.6 with the average gain score of 8.8. The rate of change was 50% higher for SIS than non-SIS 4th grade schools in the district. While it is not possible to single out the SIS intervention as the only contributing factor to the increase in scores, Principals at all schools were very generous in their praise for SIS intervention being a contributing factor for their schools' score increases.

By the time teachers enter the teaching field they have already developed a conception of teaching and learning (Perry, 1990). Quite often they have not reflected on their conception of science and delivery of equitable instruction and how their conceptions influences their conception of effective equitable science instruction. Preliminary training led us to believe that "equity" was not a much thought about topic with respect to science by all of our participants. As this study shows while teachers are accepting of examining and even embracing new conceptions of science teaching, many of the teachers still cling to their prior conception of science teaching when pressed with uncertainty in a teaching situation. This may be due to lack of practical experience, reflection, or lack of specific knowledge in the area of gender equitable science and mathematics instruction. However, exposure over a period of time helps to illiviate many uncertanties. This conclusion can support efforts to have sustained professional development on specific pedagogical issues rather than stand alone sessions on many pedagogical issues.

Research suggests that teachers' beliefs and reflections are important drivers of classroom actions and thus need to be considered in understanding changes in practice or any lack thereof (Peterson, Fennema, Carpenter & Loef, 1989; Schon, 1991). Beliefs act

as the theories that guide actions and reflections and dialogue allow an examination of those actions in terms of one's beliefs and promote necessary modifications in either actions or beliefs.

Reflection and dialoguing on their practice in the classroom, teachers expressed that they are more aware of what they need to do in the classroom to promote equitable practice that is constructivist. All of the teachers expressed that they were not always conscious of practices that exclude girls in the learning process but as they reflected upon their teaching they became more conscious of their practice and were able to adjust their teaching to include all students, not just the girls, in the learning process. The teachers said that being part of the programs design and having open dialogue with one another and the SIS staff helped them in their reflection and practice. They felt less isolated and more involved in the reform process in their classroom.

Many of the teachers said they enjoyed teaching science more. A number of teachers expressed that they have developed new ways of teaching science and mathematics throughout the year. All of the teachers expressed the belief that involving all students in the learning process was crucial for effective teaching. The teachers noticed that their students became more excited about learning when they were actively engaged in activities. They also noted that the girls seemed to blossom in the classroom when they were working on projects or in groups.

Teachers agreed that they have become more reflective of their teaching experience. However, the teachers did express the concern that when they are confronted with teaching a science topic that is new and unfamiliar they tended to revert back to a more traditional teaching approach. They also noticed that when this occurred the girls

became less participatory in the activities. Specifically related to equitable practice, teachers revealed that not all their lessons make a connection to gender sensitivity but they are still learning and trying new approaches. This was a concern expressed by all the teachers. However, they said that by just being conscious of this occurrence was helping them change their teaching practice. They tend to be mindful of what is occurring and try to change their practice.

Implications

The SIS program seeks to increase elementary girls' interest and achievement in science and mathematics, create a more positive learning climate for minority school girls and their families on academic and community/social levels, and increase the knowledge base and understanding of parents with respect to their influence in promoting girls' interest and achievement in science and mathematics. Findings to date show that the girls started the program with positive attitudes and perceptions of science and about science career possibilities. The girls did significantly increase their science and mathematics skill levels after having participated in the program. It could be stated that the girl's achievement scores on the skill test increased significantly because the girl's attitudes and perceptions were high before program implementation. If their attitudes and perceptions were low to begin with perhaps their skills would not have increased significantly.

Also, the call for systemic reform presents a great challenge in facilitating teachers' conceptions of science/mathematics teaching and practices of confronting the gender gap. In order for teachers to model practices of teaching that promotes gender equity in science and mathematics, they must participate in reflective practice. Teachers must be actively involved in the process of reform because they are the change agents of

reform in the classrooms. Reforming science/mathematics teaching that confronts the gender gap requires reforming teachers conceptions first. Unless teachers reflect upon and practice reformed teaching strategies that promote gender equity, it is unrealistic to expect change.

As schools strive to embed equitable practice into their curriculum they must actively involve teachers in the process of reform. The implementation of new teaching approaches that involve equity has to have a reciprocal relationship with teachers conceptions and actions, because teachers are the agents of reform in the classrooms. How reform in the practice of promoting equity in science education should be implemented in a classroom must be informed by teachers' conceptions of science teaching and equitable practice. Likewise, teachers need to be informed by the research on equitable practice.

Limitations

There are several limitations that may have hindered the outcome of program results. First of all there was no control group comparison; therefore, other factors unknown to the researchers could have mediated the results. In the future, there will be made allowances to include a control group. A second limitation could be a "Hawthorne" like effect. Prior to program implementation there were no hands on, integrated science and mathematics experiences taking place in the six schools. Another limitation was that matched sampling was not employed pre to post. This might have yielded more dramatic differences in progress from fall to spring. Lastly, school populations are often transient. Therefore, the fall sample may not have matched the spring sampling. In the future random sampling across all instruments may be warranted.

In the successive years of the program, the researchers will attempt to look at longitudinal affects on the girls' attitudes, perceptions, and achievement levels. Since the girls held positive attitudes towards science before program implementation it may warrant a closer look at the cultural and familial factors that my have contributed to the girls attitudes. While the program has been promising, many more questions still remain and new ones have developed. In an attempt to answer these questions, the researchers will look for ways to improve program implementation. What became evident in the program implementation was that (a) parental behavioral expectations for their daughters have important implications for females' interest and achievement in science and mathematics; (b) intervention programs that are specifically designed to include role models have a strong and positive impact on females' achievement in science and mathematics and assist females to identify with science and mathematics as possible areas for study or employment; (c) program interventions evolve in stages of development, growth, and change. In order to promote the sustained success of females in science and mathematics, there must be a conscious effort to provide support for collaboration among schools, parents, and the community as ideas for useful strategies are developed, implemented, and evaluated.

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